Mission System Overview

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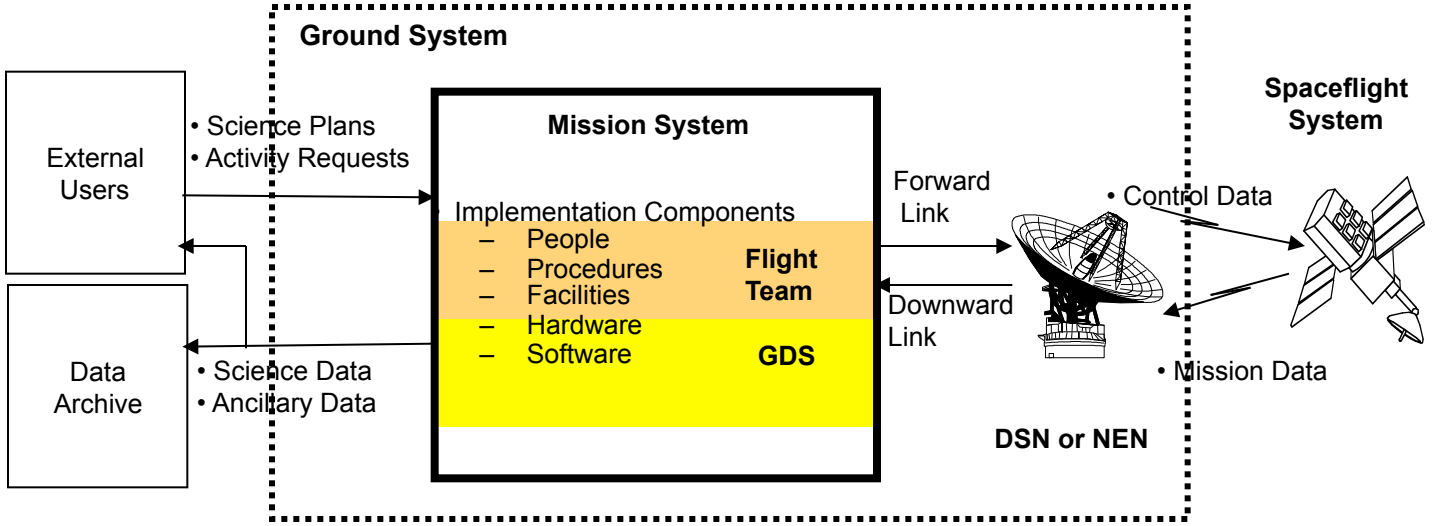
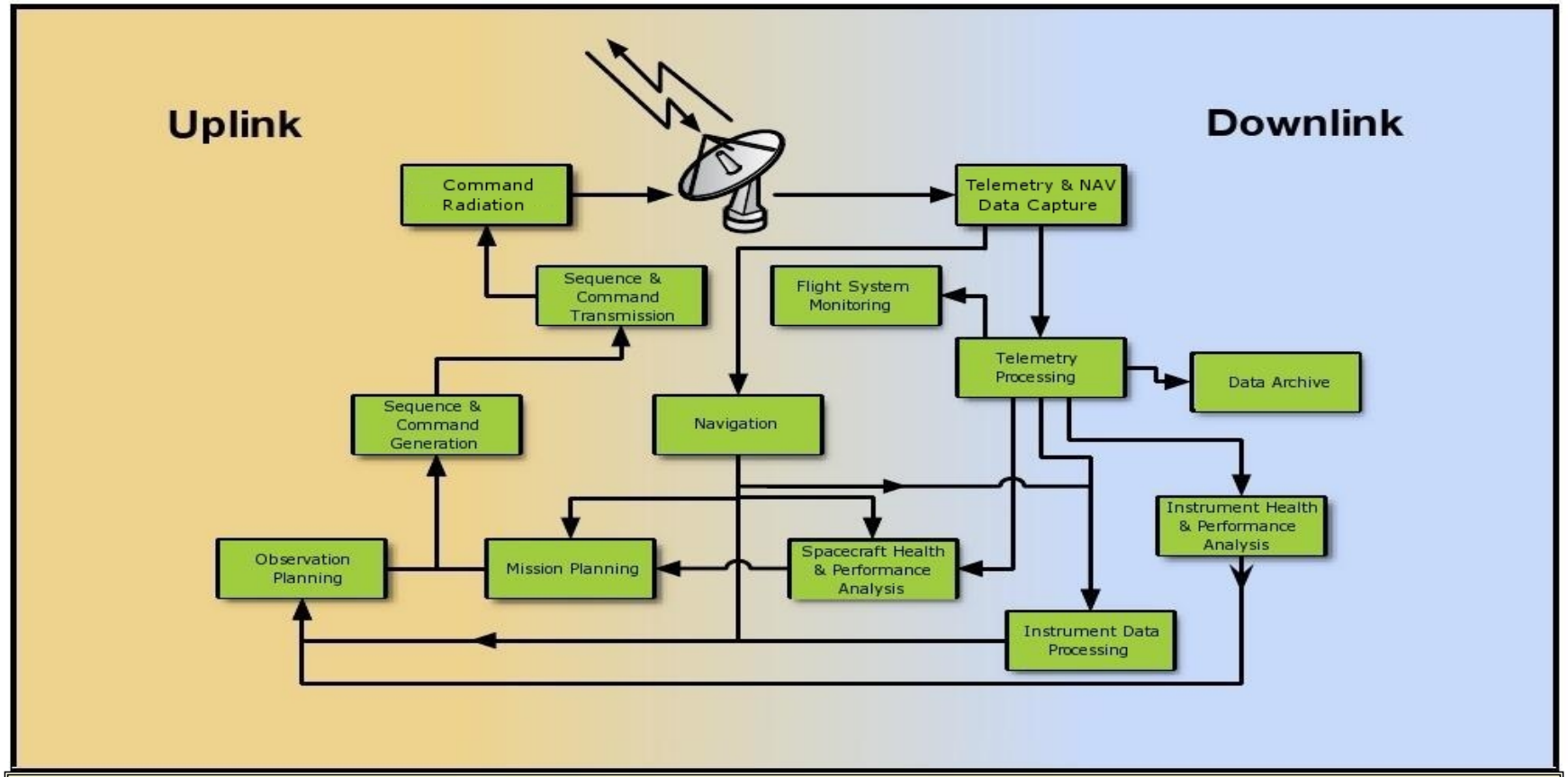


What is MGSS? And What is AMMOS?

- Product: Advanced Multi-Mission Operations System (AMMOS)
  - This is the part of the Mission System that is the core multi-mission set of hardware and software (aka multi-mission GDS)

- Organization: Multi-mission Ground Systems and Support Program Office (MGSS)
  - This is the organization that manages the multi-mission GDS

A typical decomposition of a Mission System into Functional Elements



The AMMOS is based upon a simple idea: For those elements of mission operations systems that are common to multiple projects, build them once rather than duplicating that development and maintenance effort for each project

ICAP (Interplanetary Customer Assistance Package)

OUR RECOMMENDATION FOR SMALLSATS

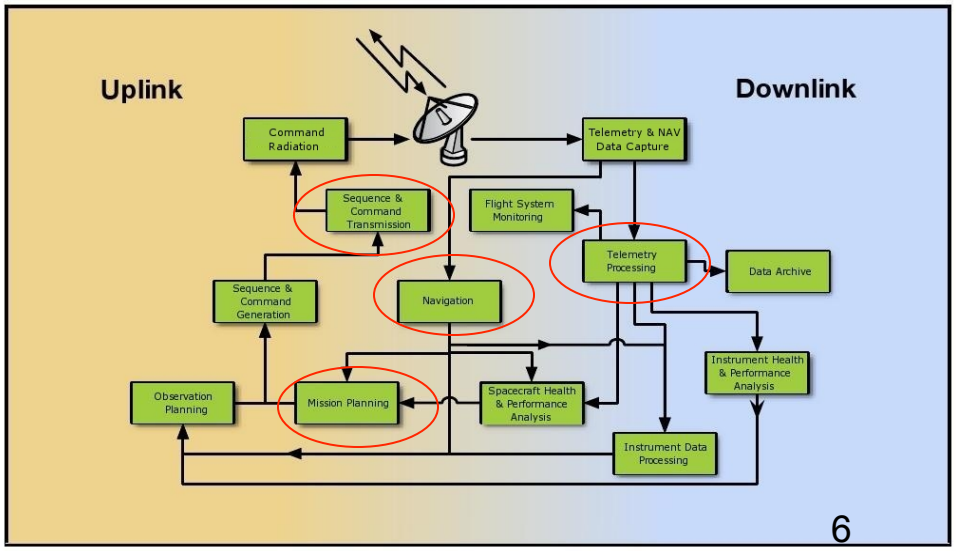
What is an ICAP?

ICAP = **I**ND **C**ustomer **A**ssistance **P**ackage

- A low cost method for JPL to support multiple low cost missions.
- Will enable a (small spacecraft) ground system engineer to install a command/telemetry system that will meet the project needs with minimal MGSS involvement that will lead to lower cost
- Will consist of selected:
  - AMMOS tools/services and description
  - User's guide

AMMOS Tools/Services Available for Smallsats

- Tools
  - Command Sequence Generator (aka MPS Editor)
  - AMMOS Mission Data Processing and Control System (aka AMPCS)
- Services
  - Navigation
  - DSN scheduling



Our Customer Base: Missions to which we Build

- Are those smallsat missions that plan to use the DSN (e.g planetary, heliophysics, astrophysics, lunar, etc.)
- Are those missions that comply with standards (e.g. CCSDS Version 2 tlm frame, XTCE)
- Are those missions for which the uplink will include SLE protocol (CLTU data format)
- Are those missions that agree that the mission adaptations will be done by the scripting agents, not the core AMMOS software

Summary of MGSS Business Model

- *MGSS will* provide an integrated cmd/tlm tool and sequencing tool to the missions
- *MGSS will* provide documentation pertinent to the software (e.g. user's guide, standards, installation guide, troubleshooting guide, software interface specs, cmd/tlm dictionary templates, etc.)
  - MGSS will provide "AMMOS 101" to expedite customer configuration with minimal hand-holding
- *MGSS will* provide a wiki site (future plans) to accommodate questions, share ideas, transfer of info, lessons learned, and FAQs. Wiki site will be open to customers only, as a community of users.
  - Outside of JPL firewall; currently unsupported
- *MGSS's* ICAP package is at no cost to the project
  - MGSS will provide (8) hours of consulting service for the ICAP package at no cost to the mission
- *MGSS will* provide optional services as requested by the missions at a nominal fee[1]
  - Navigation and Mission Design, DSN scheduling, Training, Relay services, Consultation
  - Additional systems engineering for advanced AMPCS capabilities
  - We are not currently providing MSA facility as a service
- Ground system deployment is the responsibility of the mission
- Procurement of hardware is the responsibility of the mission

[1] Contact the MGSS Mission Interface Office to get a preliminary cost estimate

Who Do I Contact?

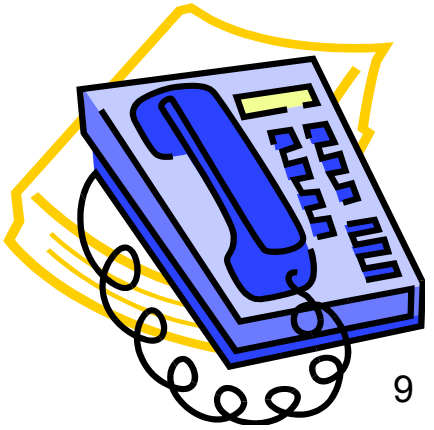
- For AMMOS tools/services, please call or email:

  MGSS Mission Interface & Commitments Office

  Eleanor Basilio 818-393-0686, ebasilio@jpl.nasa.gov

  Greg Welz 818-393-4978, gwelz@jpl.nasa.gov

- Or go to http://ammos.jpl.nasa.gov for an overview of AMMOS



An MGSS Service, Presented by Tomas Martin-Mur

MISSION DESIGN AND NAVIGATION

Summary of MDNAV Services

- MDNAV Services include:
  - Provision of the hardware, software, data, people, processes, and facilities required for the design of efficient routes for a spacecraft to a desired Solar System destination
  - Safely piloting spacecraft to that destination
- JPL MDNAV is already providing these services for NEA Scout and Lunar Flashlight
- Primary functions involved are the design, analysis, and reconstruction of trajectories and maneuvers
- Costs and accuracies for MDNAV Services will be based on numerous factors, including the mission phase in which the service is started, mission duration, objectives, constraints, destination, propulsion, complexity, critical events, tracking data requirements, etc.

An MGSS Service, Presented by Karen Yetter

DSN SCHEDULING

MRSS: Who We Are and What We Do

- Who We Are
  - MRSS Team has extensive experience in the planning and negotiation of Deep Space Network (DSN) resources.
  - 12 member team supporting 20 missions, representing a wide range of projects (NASA and Non-NASA) and mission types. Including the first interplanetary CubeSat to use the DSN, MarCO.
- What We Do: Coordinate, Schedule, and Negotiate DSN Resources
  - Coordinate mission subsystem level requirements into one integrated mission tracking strategy, including collaboration with project elements to provide solutions to technical and engineering problems related to DSN scheduling
  - Represent the project in the DSN negotiation process: Maintain tracking requirements, provide solutions for conflict resolution, and keep project aware of any potential or real constraints for DSN tracking resources.
  - Distribute tracking information to project in support of operational planning.
  - Continuous monitoring of DSN resources scheduled. 24/7 support if needed.

Benefits of Our Services to SmallSats

- DSN Scheduling
  - DSN is an oversubscribed resource. Contention levels for antenna resources can range from 30% – 70%. Active participation in the negotiation process is key to ensure requirements are met.
  - Negotiation process requires constant monitoring, schedule deadlines are fluid. Rapid response required in all negotiation phases.
  - Dynamic tracking OPS schedule: Scheduled tracks are susceptible to impact by other users and DSN at any time.
- MRSS Support
  - MRSS brings vast knowledge and experience in project scheduling, ability to work with projects to find best fit for obtaining DSN resources.
  - Cross-trained team, no single point of failure.
  - We are multi-mission dedicated DSN scheduling team, ability to provide continuous DSN schedule monitoring and negotiation on a part-time budget.
  - Ability to bring experience gained from representing MarCO cubesats.

SmallSat Operations: Cost Effective Options for DSN Scheduling

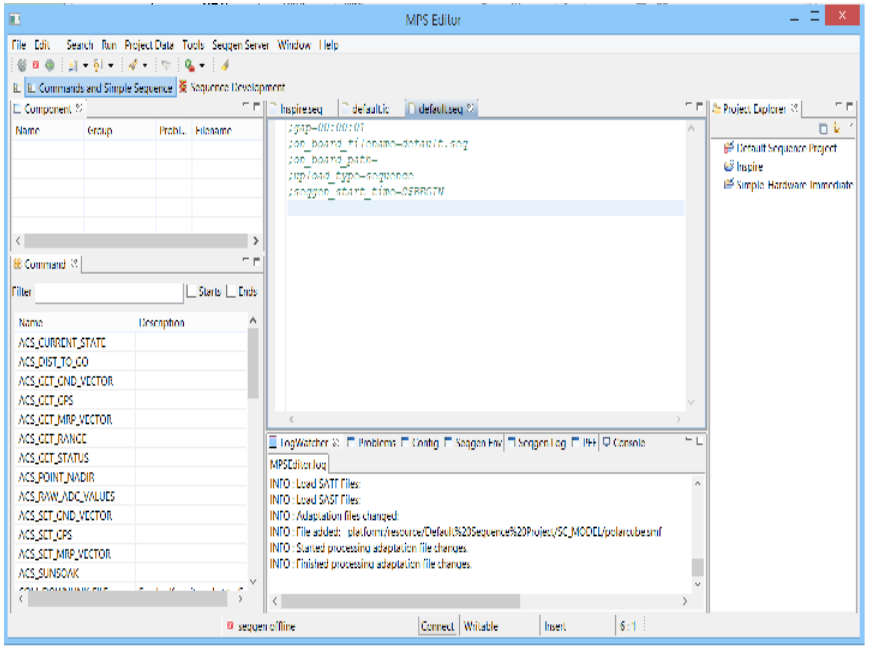
- Options to Help Reduce Cost
  - Development phase: MRSS participation as needed.
  - Operations Phase E: Full participation delayed until Launch - 8 months. DSN requires input of DSN tracking requirements at 6 months prior to track.
  - Use existing MRSS procedures and products (heritage)
  - DSN Tracking Requirement Planning: Tracking request and time spent in negotiation = dollars. To help reduce cost:
    - Reduce tracking profile to minimal acceptable level: Includes track length, number of tracks, and antenna type.
    - Maintain tracking requirements consistent with forecast.
    - Maximize flexibility/Minimize constraints: Easier to schedule and more likely for project to meet operational/ data return requirements.
  - MRSS support scalable, room for creativity 
    - Remove/reduce some services and products. Example: MRSS negotiate and monitor tracking only, no product deliveries. Project pull DSN coverage from DSN.

An MGSS Tool, Presented by Barbara Streiffert

MPS (MISSION PLANNING & SEQUENCING) EDITOR

MPS Editor

Context Sensitive Editor for Command Sequence Generation



MPS Editor
Command Sequence Generation

- Automatic import of command database
- Command sequence perspective
  - Allows drag and drop of commands
  - Checks command parameters against definition for number, type and range
  - Allows for command parameters that are signed and unsigned integers, floats, strings, times, durations, enumerated types
  - Allows relative or absolute timing as well as gaps for relative timing
  - Allows for specification of on-board file name
- Capability to communicate with and start external process for command translation or other purposes automatically
- Configuration file input for one-time adaptation

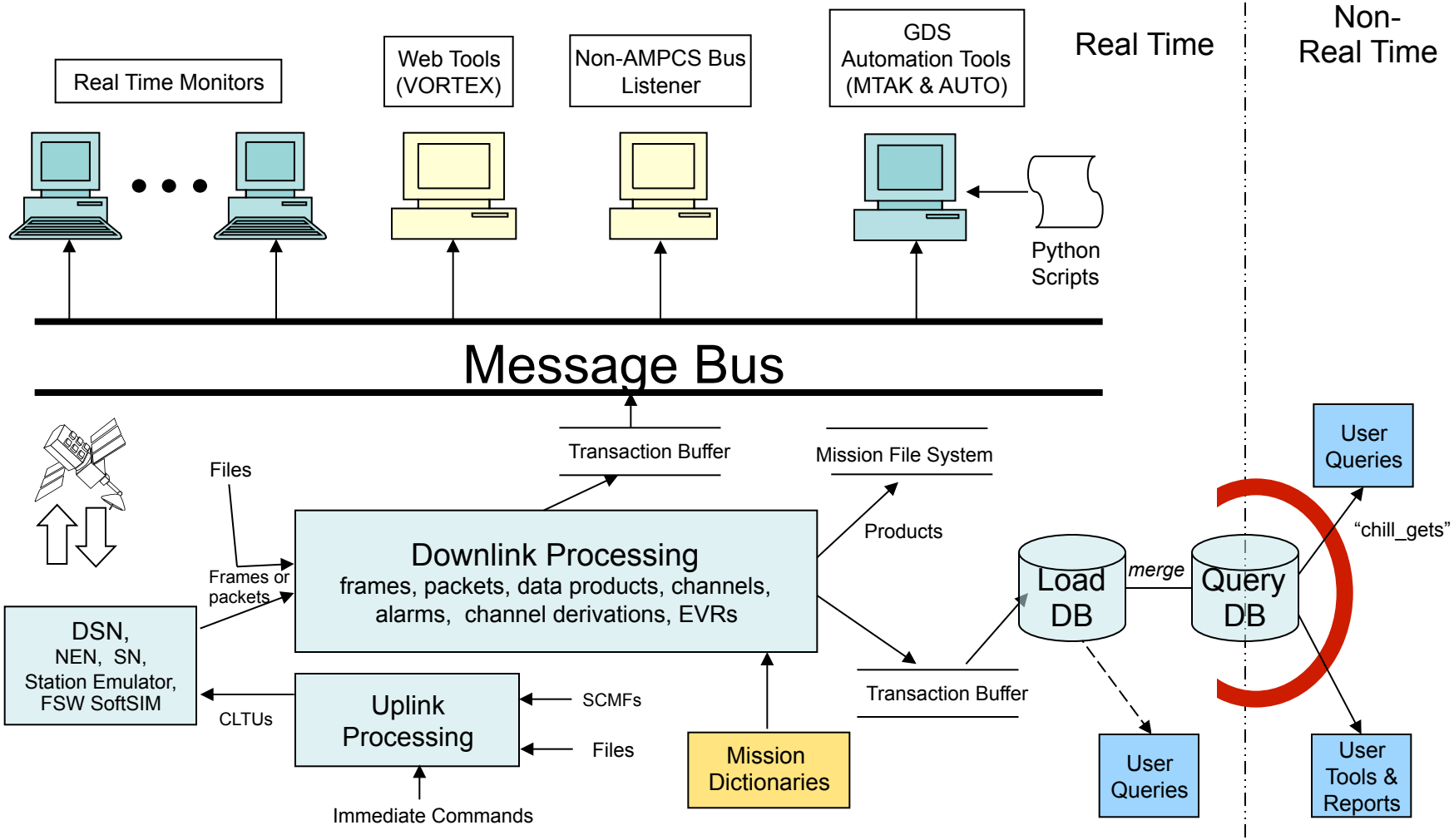
An MGSS Tool, Presented by Dave Santo

AMPCS (AMMOS MISSION DATA PROCESSING AND CONTROL SYSTEM)

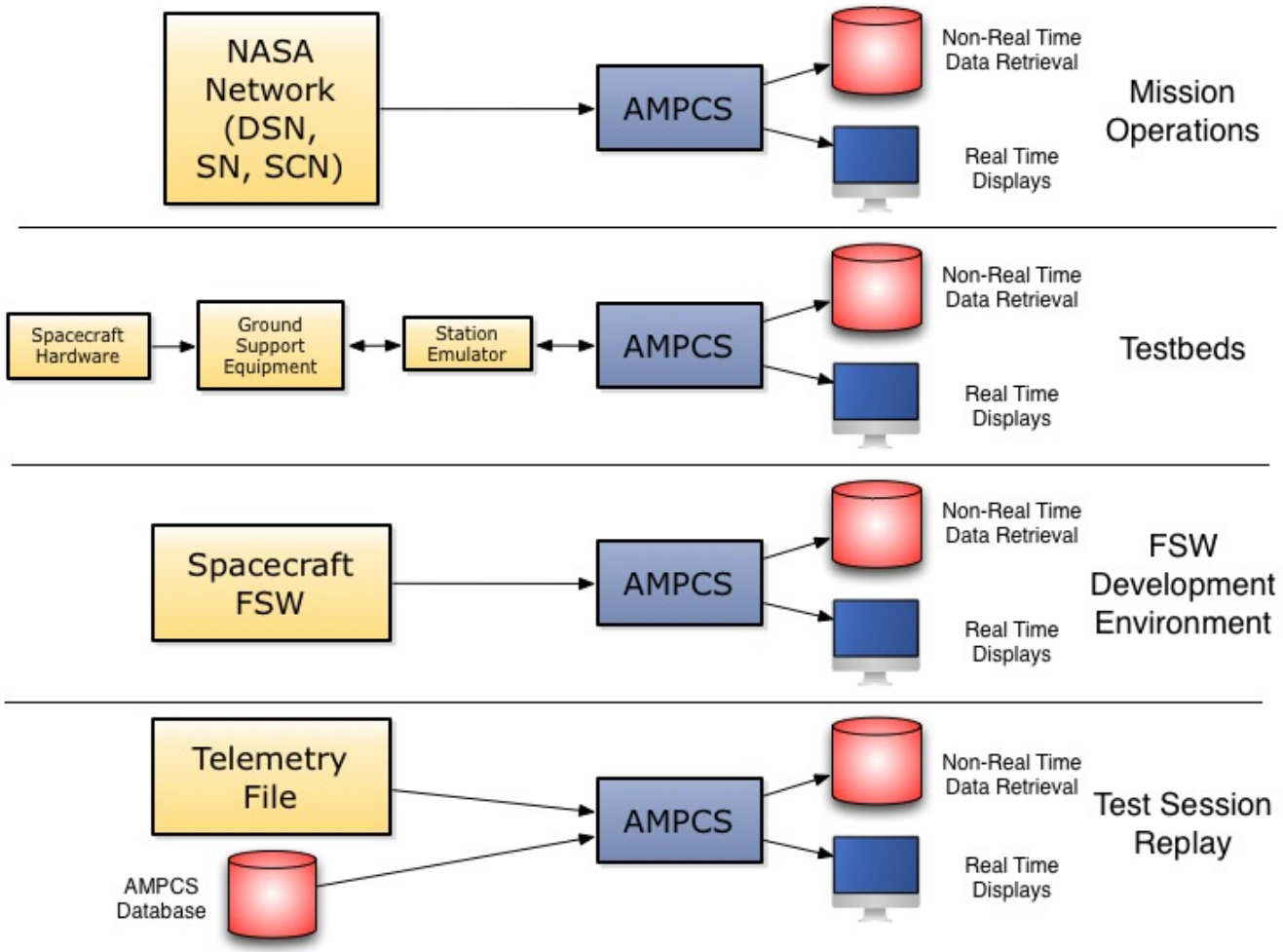
What is AMPCS?

- Flexible, full function, real-time Mission Control application
  - Flexible deployment model: from a single linux laptop, to multi-node hardware
  - Dictionary-driven (binary data formats, channel and EVR definitions, alarm definitions, derived channel definitions)
  - Supports both telemetry processing and commanding; provides realtime displays; performs ground-derived channel derivation; supports custom (Java) mission-provided derivation algorithms
  - All input, processed data, logs, messages, etc is stored, and can be queried
  - During FSW Development, Testbed and ATLO operations: test tool for flight software development, spacecraft integration and test
  - During Operations: operational system for spacecraft telemetry processing and monitoring
- Accepts CCSDS formatted in-sync frames and/or packets
  - Sources: DSN, NEN/SN, a station emulator, simple ground support equipment, files
  - Processes frames and/or packets into telemetry products (channelized data, EVRs, Products, etc.) for delivery to real time and non-real-time users
- Testbed and ATLO Telemetry Environments
  - "Test session" concept organizes access to each test's pertinent data
    - Captures all incoming and processed data, logs, FSW version used, and dictionary version used, etc.
    - Allows cross-test session analysis
  - Specialized test environment features to assist spacecraft integration and test (e.g. command fault injection, test session management, frame/packet watch displays, frame quality displays)
  - (A)MPCS Test Automation Toolkit (MTAK) for spacecraft test scripting (session dependent)
- Extensive command line queries and tools, python scripting environment
  - AMPCS Utility Toolkit for Operations (AUTO) for lights-out operations automation (session independent)

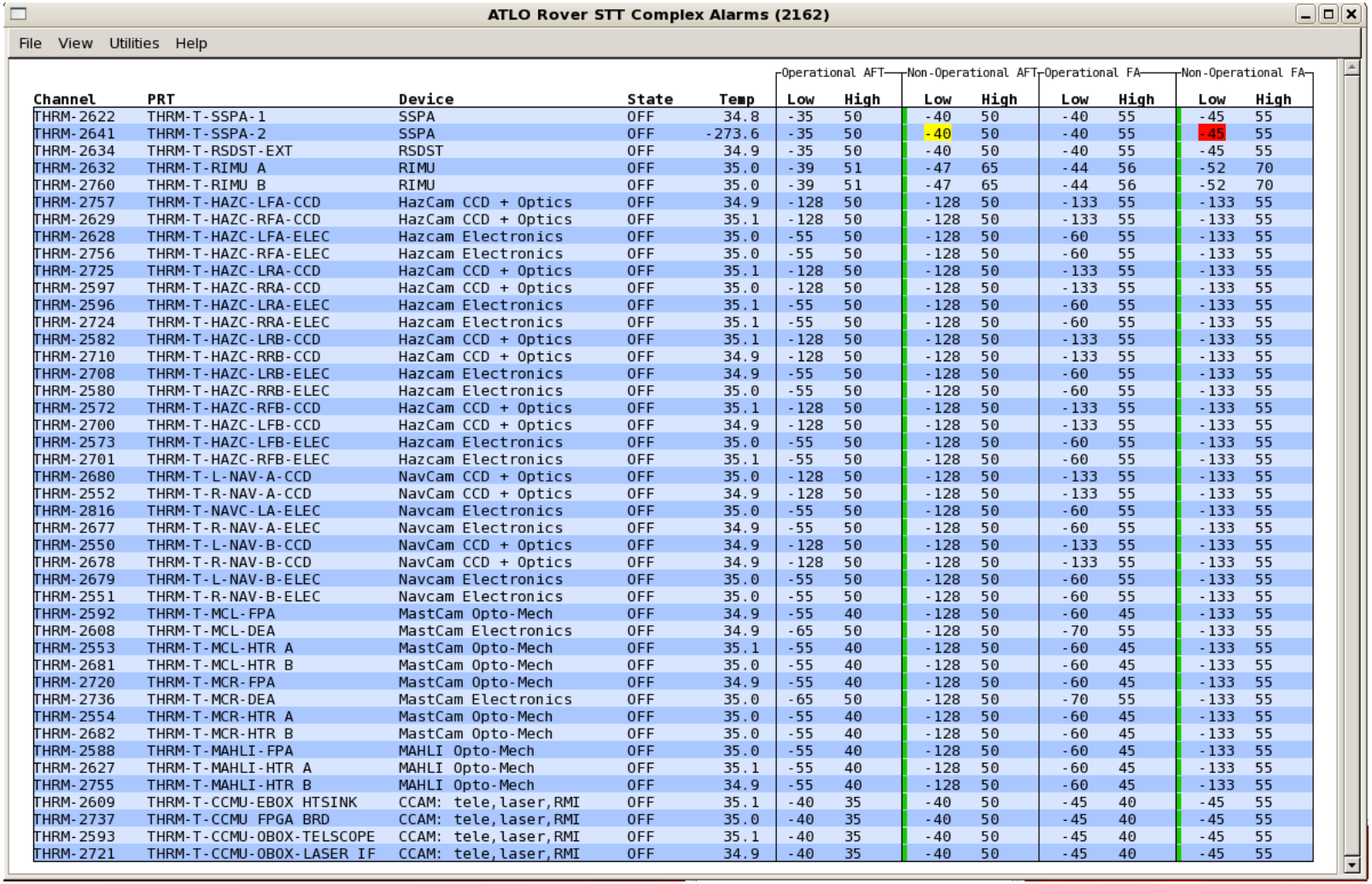
AMPCS System Architecture



Venue Support for “Test As You Fly”



Example Display (fixed page)

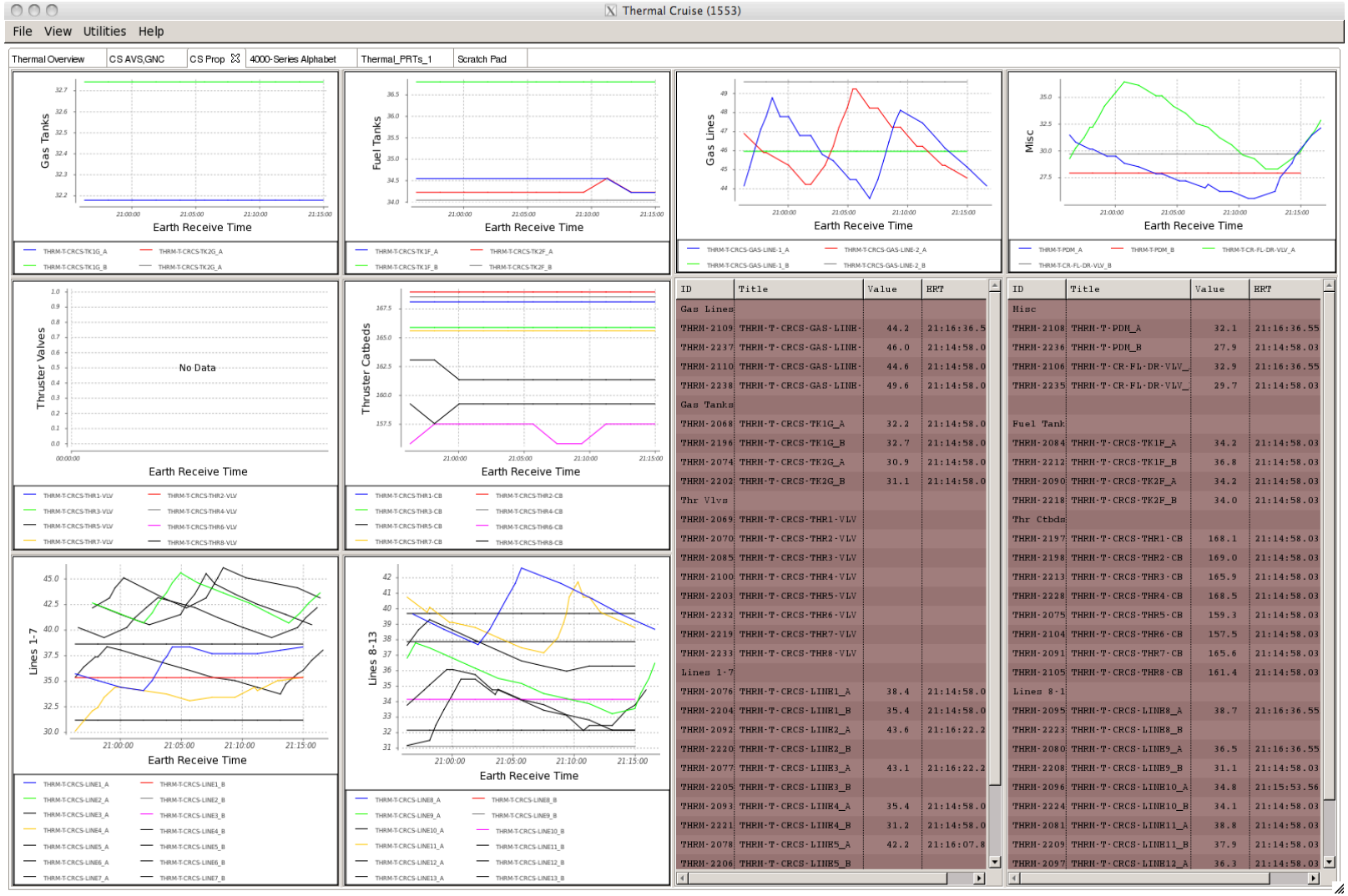


ATLO Rover STT Complex Alarms (2162)

File View Utilities Help

					Operational AFT		Non-Operational AFT		Operational FA		Non-Operational FA	
Channel	PRT	Device	State	Temp	Low	High	Low	High	Low	High	Low	High
THRM-2622	THRM-T-SSPA-1	SSPA	OFF	34.8	-35	50	-40	50	-40	55	-45	55
THRM-2641	THRM-T-SSPA-2	SSPA	OFF	-273.6	-35	50	-40	50	-40	55	-45	55
THRM-2634	THRM-T-RSDST-EXT	RSDST	OFF	34.9	-35	50	-40	50	-40	55	-45	55
THRM-2632	THRM-T-RIMU A	RIMU	OFF	35.0	-39	51	-47	65	-44	56	-52	70
THRM-2760	THRM-T-RIMU B	RIMU	OFF	35.0	-39	51	-47	65	-44	56	-52	70
THRM-2757	THRM-T-HAZC-LFA-CCD	HazCam CCD + Optics	OFF	34.9	-128	50	-128	50	-133	55	-133	55
THRM-2629	THRM-T-HAZC-RFA-CCD	HazCam CCD + Optics	OFF	35.1	-128	50	-128	50	-133	55	-133	55
THRM-2628	THRM-T-HAZC-LFA-ELEC	Hazcam Electronics	OFF	35.0	-55	50	-128	50	-60	55	-133	55
THRM-2756	THRM-T-HAZC-RFA-ELEC	Hazcam Electronics	OFF	35.0	-55	50	-128	50	-60	55	-133	55
THRM-2725	THRM-T-HAZC-LRA-CCD	HazCam CCD + Optics	OFF	35.1	-128	50	-128	50	-133	55	-133	55
THRM-2597	THRM-T-HAZC-RRA-CCD	HazCam CCD + Optics	OFF	35.0	-128	50	-128	50	-133	55	-133	55
THRM-2596	THRM-T-HAZC-LRA-ELEC	Hazcam Electronics	OFF	35.1	-55	50	-128	50	-60	55	-133	55
THRM-2724	THRM-T-HAZC-RRA-ELEC	Hazcam Electronics	OFF	35.1	-55	50	-128	50	-60	55	-133	55
THRM-2582	THRM-T-HAZC-LRB-CCD	HazCam CCD + Optics	OFF	35.1	-128	50	-128	50	-133	55	-133	55
THRM-2710	THRM-T-HAZC-RRB-CCD	HazCam CCD + Optics	OFF	34.9	-128	50	-128	50	-133	55	-133	55
THRM-2708	THRM-T-HAZC-LRB-ELEC	Hazcam Electronics	OFF	34.9	-55	50	-128	50	-60	55	-133	55
THRM-2580	THRM-T-HAZC-RRB-ELEC	Hazcam Electronics	OFF	35.0	-55	50	-128	50	-60	55	-133	55
THRM-2572	THRM-T-HAZC-RFB-CCD	HazCam CCD + Optics	OFF	35.1	-128	50	-128	50	-133	55	-133	55
THRM-2700	THRM-T-HAZC-LFB-CCD	HazCam CCD + Optics	OFF	34.9	-128	50	-128	50	-133	55	-133	55
THRM-2573	THRM-T-HAZC-LFB-ELEC	Hazcam Electronics	OFF	35.0	-55	50	-128	50	-60	55	-133	55
THRM-2701	THRM-T-HAZC-RFB-ELEC	Hazcam Electronics	OFF	35.1	-55	50	-128	50	-60	55	-133	55
THRM-2680	THRM-T-L-NAV-A-CCD	NavCam CCD + Optics	OFF	35.0	-128	50	-128	50	-133	55	-133	55
THRM-2552	THRM-T-R-NAV-A-CCD	NavCam CCD + Optics	OFF	34.9	-128	50	-128	50	-133	55	-133	55
THRM-2816	THRM-T-NAVC-LA-ELEC	Navcam Electronics	OFF	35.0	-55	50	-128	50	-60	55	-133	55
THRM-2677	THRM-T-R-NAV-A-ELEC	Navcam Electronics	OFF	34.9	-55	50	-128	50	-60	55	-133	55
THRM-2550	THRM-T-L-NAV-B-CCD	NavCam CCD + Optics	OFF	34.9	-128	50	-128	50	-133	55	-133	55
THRM-2678	THRM-T-R-NAV-B-CCD	NavCam CCD + Optics	OFF	34.9	-128	50	-128	50	-133	55	-133	55
THRM-2679	THRM-T-L-NAV-B-ELEC	Navcam Electronics	OFF	35.0	-55	50	-128	50	-60	55	-133	55
THRM-2551	THRM-T-R-NAV-B-ELEC	Navcam Electronics	OFF	35.0	-55	50	-128	50	-60	55	-133	55
THRM-2592	THRM-T-MCL-FPA	MastCam Opto-Mech	OFF	34.9	-55	40	-128	50	-60	45	-133	55
THRM-2608	THRM-T-MCL-DEA	MastCam Electronics	OFF	34.9	-65	50	-128	50	-70	55	-133	55
THRM-2553	THRM-T-MCL-HTR A	MastCam Opto-Mech	OFF	35.1	-55	40	-128	50	-60	45	-133	55
THRM-2681	THRM-T-MCL-HTR B	MastCam Opto-Mech	OFF	35.0	-55	40	-128	50	-60	45	-133	55
THRM-2720	THRM-T-MCR-FPA	MastCam Opto-Mech	OFF	34.9	-55	40	-128	50	-60	45	-133	55
THRM-2736	THRM-T-MCR-DEA	MastCam Electronics	OFF	35.0	-65	50	-128	50	-70	55	-133	55
THRM-2554	THRM-T-MCR-HTR A	MastCam Opto-Mech	OFF	35.0	-55	40	-128	50	-60	45	-133	55
THRM-2682	THRM-T-MCR-HTR B	MastCam Opto-Mech	OFF	35.0	-55	40	-128	50	-60	45	-133	55
THRM-2588	THRM-T-MAHLI-FPA	MAHLI Opto-Mech	OFF	35.0	-55	40	-128	50	-60	45	-133	55
THRM-2627	THRM-T-MAHLI-HTR A	MAHLI Opto-Mech	OFF	35.1	-55	40	-128	50	-60	45	-133	55
THRM-2755	THRM-T-MAHLI-HTR B	MAHLI Opto-Mech	OFF	34.9	-55	40	-128	50	-60	45	-133	55
THRM-2609	THRM-T-CCMU-EBOX HTSINK	CCAM: tele,laser,RMI	OFF	35.1	-40	35	-40	50	-45	40	-45	55
THRM-2737	THRM-T-CCMU FPGA BRD	CCAM: tele,laser,RMI	OFF	35.0	-40	35	-40	50	-45	40	-45	55
THRM-2593	THRM-T-CCMU-OBOX-TELSCOPE	CCAM: tele,laser,RMI	OFF	35.1	-40	35	-40	50	-45	40	-45	55
THRM-2721	THRM-T-CCMU-OBOX-LASER IF	CCAM: tele,laser,RMI	OFF	34.9	-40	35	-40	50	-45	40	-45	55

Example Display (custom grid)



FY16 and FY17 Plans

- Substantially improved realtime performance and throughput
- Support for CCSDS Space Link Extension (SLE)
  - Both Forward and Return Service interfaces
- Support for CCSDS CFDP File delivery
  - Both spacecraft-to-GDS and GDS-to-spacecraft
- Support for Operational commanding for non-smallsat missions

- High Speed Queries
  - Redesigning all data storage and query capabilities
  - Changing from MySQL to big data infrastructure
  - Will retain “chill_get” concept for backwards compatibility